Chemistry I

Indiana's academic standards for Chemistry I contain two standards, The Principles of Chemistry and Historical Perspectives of Chemistry. Ideas listed underneath each standard build the framework for the Chemistry I course.

In addition, ideas from the following four supporting themes will enable students to understand that science, mathematics, and technology are interdependent human enterprises, and that scientific knowledge and scientific thinking serve both individual and community purposes.

The Nature of Science and Technology

It is the union of science and technology that forms the scientific endeavor and that makes it so successful. Although each of these human enterprises has a character and history of its own, each is dependent on and reinforces the other. This first theme draws portraits of science and technology that emphasize their roles in the scientific endeavor and reveal some of the similarities and connections between them. In order for students to truly understand the nature of science and technology, they must model the process of scientific investigation through inquiries, fieldwork, lab work, etc. Through these experiences, students will practice designing investigations and experiments, making observations, and formulating theories based on evidence.

Scientific Thinking

There are certain thinking skills associated with science, mathematics, and technology that young people need to develop during their school years. These are mostly, but not exclusively, mathematical and logical skills that are essential tools for both formal and informal learning and for a lifetime of participation in society as a whole. Good communication is also essential in order to both receive and disseminate information and to understand others' ideas as well as have one's own ideas understood. Writing, in the form of journals, essays, lab reports, procedural summaries, etc., should be an integral component of students' experiences in Chemistry I.

The Mathematical World

Mathematics is essentially a process of thinking that involves building and applying abstract, logically connected networks of ideas. These ideas often arise from the need to solve problems in science, technology, and everyday life – problems ranging from how to model certain aspects of a complex scientific problem to how to balance a checkbook. Students should apply mathematics in scientific contexts and understand that mathematics is a tool used in science to help solve problems, make decisions, and understand the world around them.

Common Themes

Some important themes, such as systems, models, constancy, and change, pervade science, mathematics, and technology and appear over and over again, whether we are looking at ancient civilization, the human body, or a comet. These ideas transcend disciplinary boundaries and prove fruitful in explanation, in theory, in observation, and in design. These themes provide students with opportunities to engage in long-term and on-going laboratory and fieldwork and to understand the role of change over time in studying concepts in Chemistry I.

Standard 1

Principles of Chemistry

Students begin to conceptualize the general structure of the atom and the roles played by the main parts of the atom in determining the properties of materials. They investigate, through such methods as laboratory work, the nature of chemical changes and the role of energy in those changes.

Properties of Matter

C.1.1 Differentiate between pure substances and mixtures based on physical properties such as density, melting point, boiling point, and solubility.

C.1.2 Determine the properties and quantities of matter such as mass, volume, temperature, density, melting point, boiling point, conductivity, solubility, color, numbers of moles, and pH (calculate pH from the hydrogen-ion concentration), and designate these properties as either extensive or intensive.

C.1.3 Recognize indicators of chemical changes such as temperature change, the production of a gas, the production of a precipitate, or a color change.

C.1.4 Describe solutions in terms of their degree of saturation.

C.1.5 Describe solutions in appropriate concentration units (be able to calculate these units), such as molarity, percent by mass or volume, parts per million (ppm), or parts per billion (ppb).

C.1.6 Predict formulas of stable ionic compounds based on charge balance of stable ions.

C.1.7 Use appropriate nomenclature when naming compounds.

C.1.8 Use formulas and laboratory investigations to classify substances as metal or nonmetal, ionic or molecular, acid or base, and organic or inorganic.

The Nature of Chemical Change

C.1.9 Describe chemical reactions with balanced chemical equations.

C.1.10 Recognize and classify reactions of various types such as oxidation-reduction.

C.1.11 Predict products of simple reaction types including acid/base, electron transfer, and precipitation.

C.1.12 Demonstrate the principle of conservation of mass through laboratory investigations.

C.1.13 Use the principle of conservation of mass to make calculations related to chemical reactions. Calculate the masses of reactants and products in a chemical reaction from the mass of one of the reactants or products and the relevant atomic masses.

C.1.14 Use Avogadro's law to make mass-volume calculations for simple chemical reactions.

C.1.15 Given a chemical equation, calculate the mass, gas volume, and/or number of moles needed to produce a given gas volume, mass, and/or number of moles of product.

C.1.16 Calculate the percent composition by mass of a compound or mixture when given the formula.

C.1.17 Perform calculations that demonstrate an understanding of the relationship between molarity, volume, and number of moles of a solute in a solution.

C.1.18 Prepare a specified volume of a solution of given molarity.

C.1.19 Use titration data to calculate the concentration of an unknown solution.

C.1.20 Predict how a reaction rate will be quantitatively affected by changes of concentration.

C.1.21 Predict how changes in temperature, surface area, and the use of catalysts will qualitatively affect the rate of a reaction.

C.1.22 Use oxidation states to recognize electron transfer reactions and identify the substance(s) losing and gaining electrons in an electron transfer reaction.

C.1.23 Write a rate law for a chemical reaction using experimental data.

C.1.24 Recognize and describe nuclear changes.

C.1.25 Recognize the importance of chemical processes in industrial and laboratory settings, e.g., electroplating, electrolysis, the operation of voltaic cells, and such important applications as the refining of aluminum.

The Structure of Matter

C.1.26 Describe physical changes and properties of matter through sketches and descriptions of the involved materials.

C.1.27 Describe chemical changes and reactions using sketches and descriptions of the reactants and products.

C.1.28 Explain that chemical bonds between atoms in molecules, such as H_2, CH_4, NH_3, C_2H_4, N_2, Cl_2, and many large biological molecules are covalent.

C.1.29 Describe dynamic equilibrium.

C.1.30 Perform calculations that demonstrate an understanding of the gas laws. Apply the gas laws to relations between pressure, temperature, and volume of any amount of an ideal gas or any mixture of ideal gases.

C.1.31 Use kinetic molecular theory to explain changes in gas volumes, pressure, and temperature (Solve problems using $pV=nRT$).

C.1.32 Describe the possible subatomic particles within an atom or ion.

C.1.33 Use an element's location in the Periodic Table to determine its number of valence electrons, and predict what stable ion or ions an element is likely to form in reacting with other specified elements.

C.1.34 Use the Periodic Table to compare attractions that atoms have for their electrons and explain periodic properties, such as atomic size, based on these attractions.

C.1.35 Infer and explain physical properties of substances, such as melting points, boiling points, and solubility, based on the strength of molecular attractions.

C.1.36 Describe the nature of ionic, covalent, and hydrogen bonds and give examples of how they contribute to the formation of various types of compounds.

C.1.37 Describe that spectral lines are the result of transitions of electrons between energy levels and that these lines correspond to photons with a frequency related to the energy spacing between levels by using Planck's relationship ($E=hv$).

The Nature of Energy and Change

C.1.38 Distinguish between the concepts of temperature and heat.

C.1.39 Solve problems involving heat flow and temperature changes, using known values of specific heat and latent heat of phase change.

C.1.40 Classify chemical reactions and/or phase changes as exothermic or endothermic.

C.1.41 Describe the role of light, heat, and electrical energies in physical, chemical, and nuclear changes.

C.1.42 Describe that the energy release per gram of material is much larger in nuclear fusion or fission reactions than in chemical reactions. The change in mass (calculated by $E=mc^2$) is small but significant in nuclear reactions.

C.1.43 Calculate the amount of radioactive substance remaining after an integral number of half-lives have passed.

The Basic Structures and Reactions of Organic Chemicals

C.1.44 Convert between formulas and names of common organic compounds.

C.1.45 Recognize common functional groups and polymers when given chemical formulas and names.

Standard 2

Historical Perspectives of Chemistry

Students gain understanding of how the scientific enterprise operates through examples of historical events. Through the study of these events, students understand that new ideas are limited by the context in which they are conceived, are often rejected by the scientific establishment, sometimes spring from unexpected findings, and grow or transform slowly through the contributions of many different investigators.

C1

C.2.1 Explain that Antoine Lavoisier invented a whole new field of science based on a theory of materials, physical laws, and quantitative methods, with the conservation of matter at its core. Recognize that he persuaded a generation of scientists that his approach accounted for the experimental results better than other chemical systems.

C.2.2 Describe how Lavoisier's system for naming substances and describing their reactions contributed to the rapid growth of chemistry by enabling scientists everywhere to share their findings about chemical reactions with one another without ambiguity.

C.2.3 Explain that John Dalton's modernization of the ancient Greek ideas of element, atom, compound, and molecule strengthened the new chemistry by providing physical explanations for reactions that could be expressed in quantitative terms.

C.2.4 Explain how Frederich Wohler's synthesis of the simple organic compound urea from inorganic substances made it clear that living organisms carry out chemical processes not fundamentally different from inorganic chemical processes. Describe how this discovery led to the development of the huge field of organic chemistry, the industries based on it, and eventually to the field of biochemistry.

C.2.5 Explain how Arrhenius' discovery of the nature of ionic solutions contributed to the understanding of a broad class of chemical reactions.

C.2.6 Explain that the application of the laws of quantum mechanics to chemistry by Linus Pauling and others made possible an understanding of chemical reactions on the atomic level.

C.2.7 Describe how the discovery of the structure of DNA by James D. Watson and Francis Crick made it possible to interpret the genetic code on the basis of a sequence of "letters."

NOTES

C1